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RESEARCH PAPER

Expanding the US Cornbelt Biomass Portfolio: Forester Perceptions of the Potential for Woody Biomass

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Abstract With the strong emergence of the bioeconomy in the US, there is growing interest in the ability of biomass production systems to meet the legislated demand for cellulosic biofuels. While corn grain will continue to comprise the primary feedstock for biofuel in the Cornbelt, it is unlikely that a single biomass feedstock will suit all the needs of an evolving bioenergy market; thus, the potential contribution of woody biomass should be considered. To meet informational needs, we conducted structured interviews with state-employed professional foresters along the Mississippi River corridor in five Corn Belt states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin). Foresters were queried regarding the types of woody materials available, ecological considerations, the likely silvicultural systems that might support a biomass market, and their experiences with landowner management decisions as related to removing currently low-value material. Results suggest noteworthy interest in expanded woody biomass market systems within our study area. Furthermore, substantial opportunities exist to capture trimmings, small-diameter, and low-quality material in conjunction with on-going intermediate stand treatments or sawtimber harvests that are common in the region; capturing social and economic value while potentially contributing to long-term forest health. Costs for removing this material are estimated to range between $185–494/ha ($75–200/ac) depending on site conditions and accessibility. Such a wide range in costs (and therefore break-even biomass prices) suggests that some properties throughout the study region may be priced out of the market, at least in the initial stages of market

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development. Markets are distinctly lacking at present, however, and our interviewees suggested that market-pull will be required to organize a well-rounded infrastructure to harvest, process, store, and transport woody materials. This and future studies will be significant because they inform the enhancement of agricultural prosperity on small-to-medium farms and contribute to regional and national energy goals in ways that ideally improve, rather than diminish, the ecosystem services provided by woodlands in rowcrop-dominated landscapes.

Keywords Bioenergy · Family forests · Interviews · Private forestlands · State-employed foresters

Introduction

With the expansion of the bioeconomy in the US Cornbelt and beyond, mounting interest is being placed on the ability of biomass production systems to meet federally legislated growth in demand for cellulosic based fuels. Throughout this region, corn grain will continue to dominate fuel demand; yet, because of changes in the 2007 Renewable Fuel Standard, which significantly increases cellulosic contributions to ethanol and advanced biofuel quotas, demand for cellulosic biomass feedstock demonstrates strong region specific growth potential (RFA 2009).

While crop residues (e.g., corn stover) comprise the most physically abundant feedstock in the US Cornbelt region (Perlack et al. 2005), recent research centered in Iowa suggests that market contributions from crop residues could be more constrained than previously assumed (Graham et al. 2007). There exists considerable landowner/farmer concern regarding the potential agronomic (in-field) and environmental (off-field) consequences of residue harvesting; consequently, there appears to be relatively weak Iowa farmer interest in harvesting and selling crop residues (e.g., Korsching et al. 2006; Tyndall et al. 2010). In any case, it is unlikely that a single biomass feedstock will best suit all the needs of an evolving biomass energy market in the US Cornbelt region; therefore a portfolio approach to bioenergy feedstock production is needed (Schulte et al. 2006). In light of this, the potential contribution of woody biomass in the US Cornbelt must be assessed. Until now, because of the physical abundance of assumed low-cost cellulosic feedstock from crop residues, the potential for woody biomass as an energy input has been significantly under studied in this region. It is clear that woody biomass is, in terms of year-round availability and bio-processing capabilities (e.g., the inherent energy capacity of wood combined with existing conversion technologies), that can contribute to a spectrum of energy systems. Not only can wood be converted into ethanol and other bio-chemicals, woody biomass is an excellent co-firing agent at coal-burning power plants that generate electricity and as a thermal energy source capable of replacing natural gas for industrial applications (Johnson et al. 2007; Keoleian and Volk 2005; Zerbe 1991, 2006).

Beyond energy related advantages, woody biomass is an especially compelling feedstock for social and ecological reasons. For example, woody feedstock systems

offer more favorable energy return on investment compared to grain-based ethanol,[1] can be easily scheduled for harvest and offer significant joint production advantages, stabilize soil, efficiently cycle water and nutrients, provide habitat for a diverse array of species, and create a long-term, below-ground reservoir for carbon sequestration (Grigal and Berguson 1998; Groom et al. 2008; Hammerschlag 2006; Johnson et al. 2007; Keoleian and Volk 2005).

If woody biomass is to become a viable option for the US Cornbelt region, however, extensive collaboration of several hundred thousand private landowners will be required. Throughout the US Cornbelt the vast majority (>85%) of the forested landscape is privately owned (USFS 2007a). Likewise, most of the area that needs to be restored to perennial vegetation for soil and water protection is on the farms of the region. Biomass production plantings of switchgrass, prairie, or short-rotation woody crops (SRWC) could serve a dual purpose of fuel production and increased environmental services (Coyle et al. 2008; Goerndt and Mize 2008; Johnson et al. 2007; Schulte et al. 2006). Historically, Midwestern woodlot owners have pursued land use goals other than profitability—goals such as recreation, aesthetics, wildlife, hunting, and leaving a legacy have generally taken priority (Erickson et al. 2002; Moser et al. 2009). Nevertheless, many landowners (particularly farmers) hold utilitarian views of woodland; that is, many often consider woodland as part of their total land portfolio (Moser et al. 2009). In this region, however, many of these non-timber goals are increasingly being challenged by a number of regional trends in forest conditions (e.g., increased incidence and spread of invasive species, decline in tree species such as oak and hickory, increased temporal and spatial occurrence of pests and pathogens, loss of habitat composition and structure, and significant soil erosion; Blossey 1999; Knight 2007; Knoot et al. in press; McShea et al. 2007). As such, private forest landowners in the Cornbelt region may stand to gain from a developed market for woody biomass in terms of income generation and increased opportunities for multi-objective forest management including, among many possibilities, timber improvement and enhanced recreational opportunities. The ecological state of Cornbelt forests could also potentially gain from a market for woody biomass that could help pay for management practices geared toward restoring historical conditions, preserving wildlife habitat, and reducing risk from disease, pests, and invasive species; many of these practices involve harvesting small diameter trees with little to no value in existing timber markets (Davis et al. 2005). Ultimately, the amount of biomass that can be sustainably removed from a landscape is contingent upon a mix of social and ecological factors such as: landowner willingness to manage for biomass, compatibility of biomass removal with multi-use forest objectives including landowner conservation goals (e.g., water quality, carbon sequestration, wildlife habitat), topography (impacting accessibility of required equipment), ecological process needs such as nutrient cycling, and post-management environmental concerns such as erosion and spread of invasive species (Mayfield et al. 2007; Wynsma et al. 2007).

[1] Energy return on investment (EROI) is the ratio of the amount of usable energy acquired from a feedstock source to the amount of energy expended to obtain that energy resource. Comparative studies have shown that woody materials yield a more favorable EROI than grain—e.g., Hammerschlag (2006) reports on poplar feedstock returning an EROI of 4.55 (unitless) compared to a high of 1.65 for corn.

Preliminary studies examining existing forest inventories in the US Cornbelt suggest that woody biomass is a theoretically viable niche feedstock for biofuel production (Milbrandt 2005; Schulte et al. 2008). But while woody biomass appears to be physically abundant throughout this broad region, a comprehensive assessment of the ecological, economic, technological, and social scaling factors of this resource needs to be completed to appropriately inform public and private investments. We began exploring these issues using a qualitative methodology and conducting structured interviews with exceptionally knowledgeable people—state-employed professional foresters—regarding the types of woody materials available, and the likely silvicultural systems that might support a biomass market in our study region. In addition to this information the professional foresters weighed in on what they believe to be the key ecological requirements for regional ecosystems as related to biomass harvesting and removal. We also estimated baseline parcel-level management costs and examined the infrastructural capacity for woody biomass in the region based on forester experience.

The study presented here is part of a comprehensive exploratory study on the regional availability of woody biomass within parts of the US Cornbelt region for use in burgeoning energy markets. Our other studies involve: (a) analysis of USFS Forest Inventory and Analysis data, which provide a baseline of theoretical biomass available from natural systems, (b) assessment of regional primary and secondary mill residue and survey of current residue usage, (c) assessment of metropolitan urban materials (from both public and private sources) and related infrastructure, and (d) a comprehensive survey of forest landowner interests and intentions regarding woody biomass management on their properties. This examination of state-employed forester perspectives offered in-depth understanding from those with on-the-ground experience on private lands and played a strong role in developing and calibrating subsequent forest landowner surveys.

Methods

Study Area

For this study we assessed woody biomass production and supply capabilities within a central portion of the US Cornbelt through the perspectives of state-employed field foresters. The area examined is composed of the Midwest Driftless Area and the Central Dissected Till Plain ecoregions, both of which possess a substantial forest resource and active sawlog and veneer timber industries (USFS 2007b). This area was also selected for assessment because of proximity to the Mississippi River, which has served as an important transportation corridor for woody material in the past. This region offers potential advantages in comparison to other locations within the Cornbelt in terms of landowner attitudes, and transportation costs associated with woody biomass delivered to and fuels shipped from a biorefinery (Piller 2008; Schulte et al. 2008).

The Midwest Driftless Area (or Paleozoic Plateau) spans roughly 8.5 million ha (20.9 million acres) and includes several counties in southwest Wisconsin, southeast

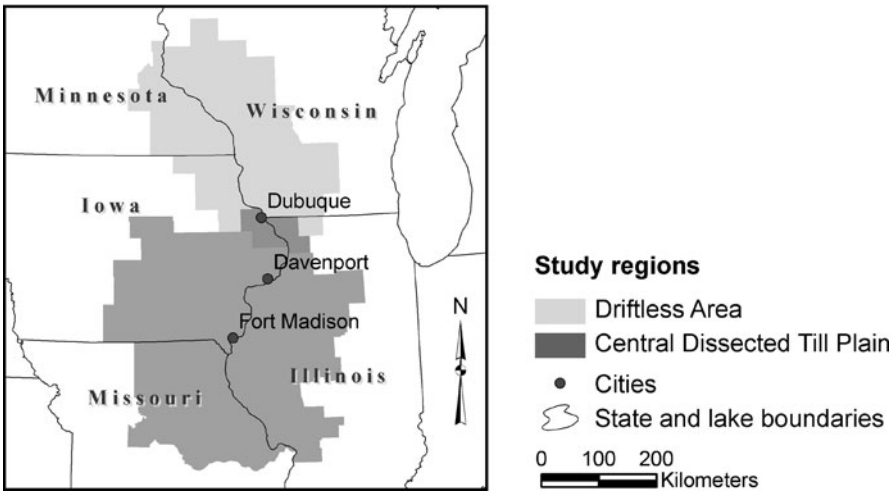

Fig. 1 Study region delineating counties within the Midwest Driftless Area and Central Dissected Till Plain. Three Iowa cities located along the Mississippi River are included for geographical context

Minnesota, northeast Iowa, and northwest Illinois (Fig. 1). The topography of this area is steeply dissected, with rowcrops and pasture covering bluff tops and valleys, and forests covering the hillsides. The eastern portion of the Central Dissected Till Plain is flat to rolling and includes counties in southeast Iowa, northeast Missouri, and western Illinois, and is just under 14.7 million ha (36.2 million acres) in extent (Fig. 1).

The Driftless Area and the Central Dissected Till Plain are 25.7 and 14.8% forested, respectively, with each containing 5.4 million acres of natural forestland. On average, 87% of these timberlands are owned by non-industrial private forest, or family, ownership (USFS 2007a). Based on US Forest Service Forest Inventory and Analysis (FIA) data (USFS 2007a), a substantial amount of live woody biomass exists in both these ecoregions, amounting to about 219 million dry metric tons in the Driftless Area and almost 236 million dry metric tons in the Central Dissected Till Plain; 51 and 47% of the live biomass, respectively, is non-sawlog biomass (live material $\leq$8 inches in diameter). Much of the biomass incorporated in the total live biomass metric, however, has accumulated over time. Net growth indicates the accumulation of woody biomass on an annual basis, and provides a coarse estimate of what could be sustainably harvested over time and regional scales. The net growth of non-sawlog species biomass on these forests is 1.06 million dry metric tons/year in the Driftless Area and 1.43 million dry metric tons/year in the Central Dissected Till Plain. Note that these correspond to relatively low growth rates of 0.19–0.26 dry metric tons tons/ha/year.

Interviews with State-Employed Foresters

A qualitative method was used to explore key factors mediating the potential woody biomass supply within the study region. Information on biomass in the region was

collected via telephone interviews with state-employed foresters whose primary responsibilities are to assist private landowners and whose jurisdictions cover the counties located in our analytical boundaries (Fig. 1), including foresters with the Illinois Department of Natural Resources (DNR), Iowa DNR, Minnesota DNR, Wisconsin DNR, and the Missouri Department of Conservation. Since formal bioenergy markets for woody biomass are not presently established in the study area, foresters who are devoted to private lands management are among the most knowledgeable entities concerning key regional factors that could expand or restrict the potential supply of currently low-value woody material. As noted in studies with similar exploratory purpose, qualitative data of this type, with an emphasis on the personal experiences of singularly knowledgeable people, can offer unique exploratory insight into complex issues for which there is little collective understanding (Hugosson and Ingemarson 2004; Strauss and Corbin 1990). Key informants such as professional foresters are often regarded as the logical starting point for the compilation of data about the social reality of specific places and regional issues (Aguilar and Garrett 2009; Elemedorf and Luloff 2001). However, as Aguilar and Garrett (2009) discuss in a recent woody biomass-related survey study regarding the opinions of state-employed foresters, it should be recognized that the information gathered here reflects varying degrees of familiarity these foresters have with the topic. Additionally, forester opinions may alternately be framed within the context of their professional obligations regarding private land management as mandated by their agency and in some cases may reflect personal opinion.

The qualitative interviews were conducted over the telephone with real-time transcription. Each interview lasted an average of 40 min and was conducted in a semi-structured, open-ended format that followed a pre-determined interview guide (see Table 1 for a full listing of questions asked). Phone interviews were made over the course of several months starting in late 2007 and concluding summer 2008. Foresters were selected for an interview based on their state agency area responsibilities in the five states. In total, a representative group of 49 state employed foresters were interviewed whose jurisdictions covered 133 of the 139 counties (96%) in our study region (9 foresters from Iowa, 24 from Wisconsin, 6 from Illinois, 3 from Minnesota, and 7 from Missouri).[2]

Following methodologies regarding the analysis of qualitative interview data suggested by Miles and Huberman (1994), our interview data were examined by assessing both commonalities and divergences in forester opinions on particular topics within and between states, and identifying the key parameters (or contingencies) that helped define individual responses. Results are presented here as summarized narrative.

[2] The disparity in the number of foresters interviewed per state is a function of how the individual states assign jurisdiction to their foresters within our study region. For example we interviewed individual foresters in all 24 study region counties in Wisconsin, all 9 district foresters responsible for the 42 study counties in IA, 6 of 9 district foresters responsible for the 36 counties in Illinois, all 3 foresters responsible for the 11 counties in MN, and all 7 foresters responsible for the 26 counties in Missouri.

Table 1 Guide for interviews with state-employed foresters

1. In natural stands, what forest silvicultural (e.g., timber stand improvement—TSI, seed tree harvest, clear cut harvest) or harvest (e.g., cut-to-length vs. whole tree, chip vs. bundle) systems do you see as offering the potential for woody biomass collection?
2. Given that the biomass energy market won't be able to compete for sawlogs, what other woody material do you see as having the potential to be collected for biomass?
3. What percentage of landowners that you work with do you expect to be amenable to woody biomass collection from natural forests?
4. What percentage and sizes of operational residue (on-site post harvest tree residue) do you feel should be left behind to protect soil and habitat qualities?
5. What portions of the landscape do you see as amenable to short-rotation woody crop plantations?
6. What percentage of landowners do you think would be interested in establishing plantations of short-rotation woody crops (SRWC)?
7. What would be some landowner motivations for engaging in the biomass market, whether from natural forests or biomass plantations?
8. Estimate farm gate prices required to attract significant interest in supplying residue wood from intermediate treatments and regeneration harvests? Estimate the costs associated with biomass related activities
9. Are there existing operators and equipment in your region that would likely engage in collecting and delivering biomass if a reasonable market develops?

Results

The viability of woody biomass in the US Cornbelt region will ultimately be a function of several unique, dynamic, and regionally variable technological, environmental, infrastructural, economic, and social factors. Taken together these factors work to constrain and therefore scale the amount of biomass available for biofuel production. The results of our interviews with state-employed foresters revealed variability in these socio-ecological factors within our study region but also uniformity in agency interest in the topic of biomass management and the possible development of regional biomass markets.

Our interviewees provided considerable information allowing for a baseline assessment of: (1) the potential for biomass harvests based on perceived social, technological, and physical management capacity; (2) the ecological limits of biomass harvest and utilization based on landscape ecological needs/constraints and existing/evolving biomass policy; (3) general biomass economics based on estimated profit motivations and a range of likely management costs; (4) existing infrastructure to support small-scale biomass harvests, on-site material processing, and regional transportation pathways; (5) the potential for short-rotation woody cropping systems (SRWC); and, (6) potential issues of interest or concern for private landowners. The following sections provide a full narrative analysis of responses.

Potential for Biomass Harvests

Most (86%) of the foresters interviewed believe that managing specifically for biomass does not seem feasible at present. However, biomass as a secondary goal to

Timber Stand Improvement (TSI) oriented management (e.g., crop tree release involving <20% stand removal of smaller, lower quality, and/or inferior species from stands typically about 16 ha (40 ac) in size) or other intermediate treatments such as invasive species eradication might be possible at 8–16 ha (20–40 ac) scales.

Much of the current timber improvement activities in these regions involve girdling trees and leaving them on site. In Iowa, for example, many weed tree/crop tree management areas typically have too few stems and are only 10 acres in typical size and most material remains on site. Because of the lack of a market, high costs, and perceived ecological advantages, most tree tops are also left on site after harvest in Iowa and Illinois. Interestingly, foresters in Wisconsin and Minnesota mentioned that many of their landowners would prefer that logging slash be removed from sites for aesthetic purposes. Nevertheless, there typically has been minimal on-site chipping, as chippers are not readily available at present or feasible to use in areas of steep terrain (e.g., throughout much of the Driftless area). Whole tree harvesting for fuller utilization is generally desirable but foresters throughout both regions believe there would be limited interest in making chips from tops or low density stands.

In the Driftless area specifically, foresters in Iowa, Wisconsin and Minnesota all stated concerns regarding accessibility due to challenging topography. These foresters did, however, express their interest in more forest management that involved clearcuts or at least crop tree release in an effort to improve degraded forest conditions caused by long histories of high-grading. In particular, foresters would prefer to use whole scale conversion of a site and simply "start over again" with even-age management in many poor quality bottomlands (e.g., from a timber perspective). To this end there may be a few large bottomland ownerships of 150 acre size that would be open to biomass management particularly in Iowa and Wisconsin. Mechanization also works best on bottomlands—foresters suggested that these areas are more amenable to skidders to remove materials and to process biomass in the field (e.g., whole or partial tree chippers or tub-chippers). There was a consensus belief that the use of key equipment such as "feller-bunchers" is not feasible in the topographically complex Driftless Area.

Of particular interest, from the perspective of the foresters interviewed, are some regional management needs that may naturally fit into a biomass market. For example, according to foresters in northeastern Iowa and southwestern Wisconsin, in many unmanaged forest stands significant reductions in existing basal area (e.g., $\geq$60%) would be needed to improve oak regeneration. It was also mentioned that TSI-related thinning cuts would theoretically fit with biomass management, assuming subsequent removal of woody material from the site. Additionally, throughout the whole study region, pathogen management may also generate large quantities of biomass. For example, ash (*Fraxinus* spp.) sanitation cuts due to the pending appearance of an exotic pest, the Emerald Ash Borer, could generate large quantities of biomass (WI DNR 2010). Ash species account for slightly over 16.1 million dry tons of biomass in our study area, or almost 4% of total live biomass (Schulte et al. 2008). Pine thinning and general aspen management were mentioned as being appropriate for Minnesota and Wisconsin.

Ecological Limits of Biomass Management

All of the foresters interviewed voiced concerns regarding site-level environmental impacts associated with biomass harvests including maintenance of soil productivity, water quality, and habitat for biodiversity. Foresters throughout the study region warned against a "one size fits all" approach to management of post-harvest tree residues, as the appropriate percentage of residue that should be left behind to protect soil and habitat quality is highly site dependent. In general, they recommended that between 33 and 50% of TSI material should remain on site; however, more should be left if there is high potential for erosion or if natural regeneration could be strongly impacted by deer herbivory, which is a major problem for regenerating oak in the Driftless area.

A "rule of thumb" noted by foresters in all states was to leave most of the finer residues for nutrient release and the coarser residues—specifically snags and older decomposing logs—for habitat. Foresters throughout the study region also suggested that the majority of nutrients potentially lost through harvest are actually returned to soils through leaf fall and that ample dead wood already exists in these forests for habitat; thus, leaving additional coarse woody debris on harvested sites is not a major concern at present.

General Biomass Economics

Foresters throughout the study region estimated that costs of small-diameter tree harvests for biomass purposes would be highly dependent upon accessibility of sites, regional equipment costs and available biomass volume (per site as well as across multiple properties). One of the biggest economic obstacles to biomass management noted by foresters in Iowa and Illinois would likely be the size of individual parcels. For example, in Iowa the average forested parcel size is about 10 acres and forested areas in general are often rather fragmented. Due to the small extent of individual ownerships, some of the foresters that we interviewed perceived issues such as small harvest volumes, limited return to landowners, infrequent harvests, and the overall costs of removal to be limiting factors in biomass management. Since biomass markets are limited to non-existent at this time, costs associated with pulp wood harvest and TSI operations (contingent upon biomass removal) can be used as a proxy. Yet, because of the contingencies listed above, foresters estimated a significant range of potential biomass harvest costs—from a low of $185/hectare to a high of $494/hectare ($75–300/acre) involving mixed species of low quality, non-sawlog material (that range from 5 to 24 cm (2–12 in) in diameter). Such a wide range in costs (and therefore break-even biomass prices) suggests that some properties throughout the study region may be priced out of the market, at least in the initial stages of market development. It is likely, however, that the costs of biomass management (e.g., harvest, field removal, and initial processing such as chipping) will decrease as the market and infrastructure for woody materials expands (Evans 2008). Interestingly, as part of a standard TSI operation, many of the foresters expected that the biomass itself usually would not carry an economic value to a landowner (or therefore material cost to the logger) and in some cases may even carry a negligible landowner fee in

exchange for the rights to remove the biomass from the site (e.g., landowner pays to have slash removed). One issue, however, was made clear by the majority of foresters: in order to make biomass recovery profitable at the very least the capacity for "in the woods" chipping would need to be widely available.

Available Infrastructure to Support Biomass Extraction

Based on forester assessment, the amount of physical infrastructure to facilitate biomass harvesting and pre-processing (e.g., equipment that handles small diameter trees, moves slash, chips or bundles materials on-site as well as vehicles that can handle transporting bulk materials of many forms) varies considerably across the study region. While equipment (e.g., hydraulic attachments designed for Vermeer and John Deere tractors, Bobcats) for harvesting small diameter ($\approx$20–23 cm; $\approx$8–9 in) biomass material from natural forests or plantations were cited as readily available across the region, the availability of equipment for collecting and delivering biomass was questionable. Log buyers from throughout the study region would likely have a stake in biomass particularly if pulp materials are mixed in a timber sale. Log buying, logging, and material hauling are usually third party arrangements to the landowner and may well involve three different entities (though many logging operations are fully integrated).

Currently the infrastructure for facilitating a biomass market is lacking in Iowa and northeast Missouri. In particular, improvements in on-site chipping technology would be required if biomass harvesting were to become prevalent. Foresters across the whole study region were aware of people/companies who could contract for volume processing of biomass materials in the field (e.g., chipping). For example, there are several companies located in northwestern Illinois that specialize in land clearing and have the appropriate equipment to facilitate more directed biomass harvesting (e.g., feller-bunchers, grinders, chippers specializing in the mulch market). Additionally, at least three major operators were known to be working in southeastern Minnesota. Without a local market for biomass, however, foresters cited that there was little incentive for biomass management largely because of high material transportation costs. Wisconsin foresters indicated that the "potential" for expanded infrastructure in the southwestern part of the state is strong because of proximity to a well-developed pulpwood infrastructure in central and northern Wisconsin. At this juncture, most of the necessary infrastructure would have to (at least initially) move south from those regions. If a localized market for materials did develop, then some foresters in this part of Wisconsin believed there are "plenty" of people and available equipment to facilitate the harvesting, preparing, and hauling of biomass material.

Potential for Short Rotation Woody Cropping Systems

Foresters in Iowa, Illinois, Missouri, and Wisconsin identified several ideal physical locations in their regions for Short Rotation Woody Crop (SRWC)[3] plantations;

[3] Short rotation woody crops (SRWC) plantations utilize fast growing trees such as hybrid poplars, willows, and other species, specifically grown to be an energy feedstock (or pulp). Tree species are often

these being flood plains, "marginal" crop land, and/or land currently in the Conservation Reserve Program (CRP). For physical and geographical context, CRP land currently under contract can serve as a coarse estimate of the extent of marginal farmlands in our study region. The Central Dissected Till Plain poses the highest density of CRP acres, with over 8,09,000 ha (2 million ac) enrolled at present (Schulte et al. 2008). The density of CRP acres are also high in some portions of the Driftless Area, however, with 3,53,000 ha (8,71,000 ac) enrolled across these counties (Schulte et al. 2008).

Foresters in Iowa, Illinois and Minnesota particularly mentioned that farmers would likely be the landowners most interested in SRWC systems, suggesting the potential for considerable land-use competition for marginal land currently used for other purposes (e.g., crops, grass buffers and other conservation practices). As stated by one forester in southwest Minnesota, SRWC plantations simply have "…not taken off. The idea has been proposed a couple times over the past 15 years but (on marginal farmland) corn/beans simply pay too much". Additionally because CRP does not currently allow biomass harvest for commercial gain, land currently under contract would not be available until the end of existing contracts (though landowners could choose to break contracts and pay concomitant penalty fees).[4] Several foresters noted it is possible that landowner interest in SRWC could significantly increase if CRP requirements were adjusted to allow for woody biomass management.[5] Even so, foresters in Minnesota suggested that switchgrass (*Panicum virgatum*) "plantations" would have a higher potential than woody systems because of quicker returns and the ease in which herbaceous materials can be pelletized for easy transport and energy use. Several foresters throughout the study region additionally suggested that if SRWC plantations were shown to have positive hunting potential—either as hunting grounds themselves and/or as key travel corridors for game species—there would likely be broad support for increasing their acreage. It was noted by foresters in Iowa that many of the new tree plantings in northeast Iowa were for the purpose of expanding wildlife habitat (e.g., about 10 million tree seedlings/year are planted for wildlife based on CRP contracts).

In terms of SRWC species, hybrid poplar (*Populus* spp.) was most frequently ($\approx$50%) mentioned as the likely candidate species for planting in bottomland areas throughout the whole study region, though half of foresters in Iowa and Illinois did mention concerns about the long-term productivity of certain clonal varieties. In Wisconsin, black locust (*Robinia pseudoacacia*) was also mentioned as a species with strong potential in this context because of its coppicing ability, nitrogen-fixing

Footnote 3 continued
chosen because of their ability to coppice. Depending on region and management, SRWCs can grow rapidly with rotations that range from 3 to 12 years (Kuhn et al. 1998).

[4] For reference, $\approx$98,000 acres in CRP contracts within the Iowa study region alone will expire in September 2010 (FSA 2010).

[5] The 2008 Farm Bill has provisions that allow certain commercial uses of CRP land planted to grass (e.g., grazing, haying) but with a 25% reduction in the CRP rental payment (10% reduction for grazing under emergency drought conditions) (FSA 2010). Currently there are not similar mid-contract provisions for CRP lands planted to trees.

ability (reducing the need for long-term fertilization inputs), and overall hardiness (i.e., general ability to withstand a variety of climate-related stressors); these beliefs are supported in the literature (e.g., Barrett et al. 1990).

General Comments Regarding Landowners in the Region

Within the states included in our study region, other entities such as log buyers, brokers, loggers, and private contractors often have more direct contact with landowners in terms of actual management activities than do state-employed foresters (Pers. Comm. 2010. Jesse Randall, Extension Forester, Iowa State University). It is also likely that such entities will initiate and manage the logistics of acquiring biomass "at the farm gate" as well as arrange for any needed primary processing of biomass, material transportation and sale to various end users. Nevertheless, based on their personal experiences with landowners in our study region, foresters were asked to share what they believe to be some of the potential points of interest or specific concerns that landowners might have regarding woody biomass management and sale. In general, the state service foresters throughout the study region mentioned the following as potential factors influencing landowner decision making regarding management for woody biomass:

- The degree to which biomass management is synergistic or creates trade-offs with other land use goals such as: recreational uses (specifically hunting), site aesthetics, wildlife habitat diversity, and increased timber values;
- The degree to which landowners might value a personal contribution toward regional "green energy" production;
- The total costs to the landowner regarding biomass harvest, biomass removal, and on-site processing; concomitantly, there will likely be a continuum of financial acceptability ranging from breakeven up through varying degrees of acceptable profit;
- Availability of landowner education regarding biomass management and marketing;
- The degree to which absentee landowners believe they can monitor what was being done on their property;
- Landowner reaction to social concerns regarding tree harvesting in general; and,
- Specific to SRWC plantations, there may be potential community backlash involving low social acceptability of managed plantations, particularly in regard to concern about natural forests being converted to plantations and apprehension regarding potential use of non-native species or genetically modified trees.

Additionally, foresters interviewed in Iowa and Illinois in particular noted that one of the biggest constraints to private biomass management would likely be the size of individual parcels and/or the dual use of land for grazing. Based on their experiences with private landowners, these same foresters stated that likely disincentives for landowners to engage in a biomass market are largely economic (e.g., too small a return, infrequent harvests, and the costs of removal). Interestingly, there are likely biomass-related issues that landowners across the region may have divergent opinions on. For example, there are unique perspectives on the role of

aesthetics in how landowners might feel about biomass harvest/removals. In Iowa and Illinois foresters believe there would likely be strong concern "across the board" regarding perceived negative effects that biomass harvesting can have on site aesthetics; whereas in Wisconsin, several foresters mentioned that the landowners they work with by and large would welcome biomass removal as a way to improve site aesthetics, particularly after timber harvest. All in all, these landowner-related issues are being pursued for further examination with landowner-based surveys taking place throughout Iowa, starting summer 2010 (LCSA 2010).

Discussion

Markets are distinctly lacking at present and it is perceived by regional foresters that market-pull will be required to organize a well-rounded infrastructure to harvest, process, store, and transport woody materials. Additionally, while short-rotation woody biomass crops offer important advantages and thus serve as a critical component of the overall feedstock supply system, at present the land area that might support such a land use is in considerable demand (Secchi et al. 2008). Yet, it should be noted that research in the region on short-rotation woody crops has demonstrated a potential for producing 8.5 dry tons/ac/year with selected cottonwood clones on riparian sites and up to 133 dry tons/ac at age 10 for the 'Crandon' clone of hybrid aspen grown on upland sites (Coyle et al. 2008; Goerndt and Mize 2008).

Many regional assessments regarding the potential of woody biomass to contribute toward renewable energy goals are becoming available. The US Northeast (Benjamin et al. 2009; Costellano et al. 2009; Munsell and Germain 2007), the US Southeast (Galik et al. 2009), US Lake States (Becker et al. 2009; Halvorsen et al. 2009; Willyard and Tikalsky 2006) are all advancing in understanding the theoretical and technically available resource base and various biomass supply constraints specific to these regions. Based on these assessments, the market availability of woody biomass in heavily forested regions tends to be enhanced by well established and diversified forest industries (from extraction through processing) and therefore these regions are positioned with high equipment capacity, trained labor pools, and specialized transportation systems. In our study area, and likely throughout the whole Cornbelt region, there are less well-defined forest industry infrastructures currently in place to facilitate biomass related start-ups; e.g., forest cover over the whole multi-state central Cornbelt region has been estimated at <24% and is highly fragmented (Iverson et al. 1994; Riitters et al. 2002). Nevertheless, Fort Madison, a metropolitan area centered in the Central Dissected Plain supported an International Paper pulp mill until 2005. The mill had been operated with a product capacity of 77,000 tons/year which equates approximately to 1,54,000 tons of wood supplied (CPBIS 2007). So there appears to be at least some remnant or latent infrastructural capacity within our study region to move woody materials.

With regard to general economic viability of woody biomass in the US Cornbelt region, the general volatility of forest product markets due to the increasingly

globalized nature of the forest industry as well as regional shifts in demand for both wood-based raw materials and final demand can cause fluctuation in prices and thus availability (AP 2008; Ince 2003). The physical and economic availability of other biofuel feedstocks can also cause regional shifts in the relative affordability of woody biomass (English et al. 2006). Without an existing biomass market it is difficult to estimate potential prices for woody materials. The appropriate round-wood comparison raw material for biomass is, at this time, pulpwood (Barmore 2008; Bergman and Zerbe 2008). Pulpwood trees are any commercial tree species that do not have the size (typically $\leq$8 in diameter) or quality (e.g., due to stem defects) to make other wood products. Sawtimber stumpage (the price of a tree on the stump), depending on species, can be an order of magnitude higher than pulpwood stumpage. Using published pulpwood prices for Illinois as a proxy for the US Cornbelt, mixed species pulpwood is priced free-on-board (delivered to the mill) at $26.45 per green metric ton ($24/green US Short ton) (USDA NASS 2009). It should be noted that regionally, pulpwood prices have rapidly responded to industry contraction. For example, the Minnesota Department of Natural Resources reports that a large drop (57%) in aspen pulpwood stumpage from the period July 2005–June 2006, as compared to October 2006–March 2007, was the result of temporary and permanent closing of several oriented strand board plants and a general slowdown in production at several regional mills (Schoeppner 2006).

Conclusion

Because of the physical abundance of assumed low-cost cellulosic feedstock from crop residues, the potential for woody biomass as an energy input has been largely discounted in the US Cornbelt; yet, it is anticipated that as competition for cellulosic feedstocks increases and energy feedstock portfolios develop, woody materials will be required to complete regional requirements. Synergistically, this growing need for cellulose creates opportunities for forest management activities that will increase residual tree growth rates, wood quality, and future income for private landowners. It also creates opportunities for the exploitation and wholesale clearing of the resource. To prevent the exploitation and the further degradation of small and medium scale farm woodlots, land managers require improved knowledge of the opportunities and implications of various degrees of thinning on the forest ecosystem. Largely because of ecological concerns, many states including three in our study region (e.g., Minnesota, Wisconsin, and Missouri) have developed biomass harvest standards designed to maximize the amount of biomass that can sustainably be harvested over the long run without negatively affecting the ecological quality of the forest site (Evans and Perschel 2009). Guidelines specific to highly fragmented row-crop dominated landscapes that compare short-term financial gain of various thinning intensities to short- and long-term impacts on residual stands, individual tree form, overall forest health, as well as broader landscape implications regarding soil erosion, water quality and agricultural prosperity, are needed. This and future studies will be significant because they inform the enhancement of agricultural prosperity particularly on small and medium

farms and contribute to regional and national energy goals in ways that ideally improve, rather than diminish, the ecosystem services provided by the forest woodlands in rowcrop-dominated landscapes.

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